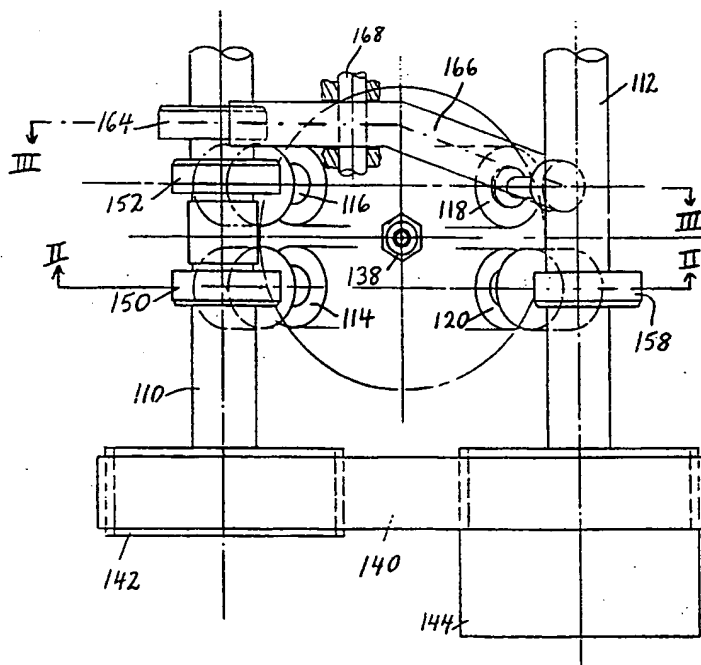




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>5</sup> :  F01L 1/26, 1/34</p>	<p>A1</p>	<p>(11) International Publication Number: <b>WO 90/10141</b>  (43) International Publication Date: 7 September 1990 (07.09.90)</p>
<p>(21) International Application Number: PCT/GB90/00269 (22) International Filing Date: 19 February 1990 (19.02.90) (30) Priority data: 8830261.7 21 February 1989 (21.02.89) GB (71) Applicant (for AT BE CH DK GB IT LU NL SE only): FORD MOTOR COMPANY LIMITED [GB/GB]; Eagle Way, Brentwood, Essex CM3 3BW (GB). (71) Applicant (for CA only): FORD MOTOR COMPANY OF CANADA LIMITED [CA/CA]; The Canadian Road, Oadville, Ontario L6J 5E4 (CA). (71) Applicant (for DE only): FORD WERKE AG [DE/DE]; Werk Köln-Niehl, Henry Ford Straße, Postfach 60 40 02, D-5000 Köln 60 (DE).</p>		<p>(71) Applicant (for ES JP only): FORD MOTOR COMPANY [US/US]; County of Wayne, Dearborn, MI 48120 (US). (71) Applicant (for FR only): FORD FRANCE S.A. [FR/FR]; B.O. 307, F-92506 Rueil-Malmaison Cédex (FR). (72) Inventor; and (75) Inventor/Applicant (for US only): MA, Thomas, Tsoi-Hei [GB/GB]; 1 Collingwood Road, South Woodham Ferriers, Chelmsford CM3 5YB (GB). (74) Agent: MESSULAM, Alec, Moses; A. Messulam &amp; Co., 24 Broadway, Leigh on Sea, Essex SS9 1BN (GB). (81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.  Published With international search report.</p>

(54) Title: TWIN CAM MULTI-VALVE INTERNAL COMBUSTION ENGINE



(57) Abstract

A twin cam engine is described having a primary and a secondary inlet valve (118, 120) for each engine cylinder and means (144) for varying the opening phase of the secondary inlet valves (120) relative the primary inlet valves (118). The first of the overhead camshafts (110) is provided with cams (150, 152, 164) for all the exhaust valves (114, 116) and the primary inlet valves (118) and the second camshaft (112) is formed with cams (158) for only the secondary inlet valves (120), whereby phase shifting of the second camshaft (112) relative to the first camshaft (110) causes a phase shift between the secondary inlet valves and the primary inlet valves without affecting the exhaust event.

***FOR THE PURPOSES OF INFORMATION ONLY***

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MR	Mauritania
BE	Belgium	GA	Gabon	MW	Malawi
BF	Burkina Faso	GB	United Kingdom	NL	Netherlands
BG	Bulgaria	HU	Hungary	NO	Norway
BJ	Benin	IT	Italy	RO	Romania
BR	Brazil	JP	Japan	SD	Sudan
CA	Canada	KP	Democratic People's Republic of Korea	SE	Sweden
CF	Central African Republic	KR	Republic of Korea	SN	Senegal
CG	Congo	LI	Liechtenstein	SU	Soviet Union
CH	Switzerland	LK	Sri Lanka	TD	Chad
CM	Cameroon	LJ	Luxembourg	TG	Togo
DE	Germany, Federal Republic of	MC	Monaco	US	United States of America
DK	Denmark				

**TWIN CAM MULTI-VALVE INTERNAL COMBUSTION ENGINE**Field of the invention

- 5 The invention relates to a twin cam engine having a primary and a secondary inlet valve for each engine cylinder and means for varying the opening phase of the secondary inlet valves relative the primary inlet valves.

10 Background of the invention

It is has been proposed in EP-A-0 262 769 that by allowing the inlet valve to remain open during part of the compression stroke of a four stroke engine, it is possible  
15 to reduce the trapped mass of the charge and thereby achieve part load performance without throttling the intake passage. This can be achieved in the case of an engine with two intake valves per cylinder by introducing a major phase shift between the two inlet valves.

20

In known combustion engines of the type having three or four valves per cylinder operated by twin camshafts, it is usual for there to be an inlet camshaft controlling all the inlet valves and an exhaust camshaft for the exhaust  
25 valves. If in such a lay out, one wishes to vary the phase of the secondary inlet valves relative to the primary inlet valves, then concentric cams are required which makes for a complicated and expensive construction. The strength of the camshafts is also impaired, tending to  
30 reduce the engine reliability.

GB-PS-347,806 describes an engine in which each cylinder has two pairs of valves arranged at the four corners of a square, the valves of each pair being symmetrically  
35 arranged about the engine centre line. Two overhead camshafts are provided each operating one inlet and one exhaust valve, and the camshafts can be phase shifted relative to one another in order to vary the duration of

the intake and exhaust events. In this prior art proposal, it is not possible to vary the inlet event without varying the exhaust event. If the intake event is to be prolonged sufficiently to permit part of the intake charge to be expelled, then this can only be done by prolonging the exhaust event by the same amount. This would inevitably lead to excessive valve overlap which would cause increased internal exhaust gas recirculation and the undesirable presence of an excess of exhaust gases in the induced charge.

#### Object of the invention

The present invention seeks to provide an engine in which the phasing of second intake valve can be regulated to vary the intake event duration without affecting the exhaust event.

#### Summary of the invention

According to the present invention, there is provided a twin cam engine having a primary and a secondary inlet valve for each engine cylinder and means for varying the opening phase of the secondary inlet valves relative the primary inlet valves, wherein the first of the overhead camshafts is provided with cams for all the exhaust valves and the primary inlet valves and the second camshaft is formed with cams for only the secondary inlet valves, whereby phase shifting of the second camshaft relative to the first camshaft causes a phase shift between the secondary inlet valves and the primary inlet valves without affecting the exhaust event.

It is possible for the layout of the ports to be conventional, that is to say with all the inlet valves lying on one side of the engine and the exhaust valves on the other. In this case, the cams on the first camshaft can act on the primary inlet valves by way of rockers.

Such a configuration is however difficult to achieve because of packaging problems and it is preferred that the valves on one side of the engine should be the secondary valves operated directly by the second camshaft and that  
5 both the exhaust valves and the primary inlet valves should be arranged along the other side of the engine for operation by the first camshaft.

In the latter case, the intake ports for the primary  
10 valves should preferably cross the engine centre line to the same side as the intake ports for the secondary inlet valves in order to enable conventional inlet and exhaust manifolds to be employed. The primary and secondary valve of an individual cylinder may, if necessary, share the  
15 same duct but alternatively it is possible to provide separate ducts for each valve opening on to the same side of the engine.

It is preferred to provide only a single exhaust valve per  
20 cylinder as the provision of four valves makes location of the spark plug troublesome. It is however possible to provide two exhaust valves per cylinder and in this case the exhaust valves preferably share a common exhaust port which may be bent to afford space for the spark plug.

25

#### Brief description of the drawings

The invention will now be described further, by way of  
example, with reference to the accompanying drawings, in  
30 which :

Figure 1 shows a schematic plan view of one cylinder of an internal combustion engine of the invention,

35 Figure 2 is a section along the line II in Figure 1,

Figure 3 is a section along the line III-III in Figure 1,

Figure 4 is a schematic representation of the cylinder head of a second embodiment of the invention,

5        Figure 5 is a similar view of third embodiment of the invention, and

Figure 6 is a schematic drawing showing the preferred arrangement of the ports in an engine having four  
10        valves per cylinder.

#### Description of the preferred embodiments

Figures 1 to 3 show partially an engine having two  
15        overhead camshafts 110, 112 and four valves 114, 116, 118 and 120 per cylinder. The valves 114, 116 are exhaust valves and the valve 118, 120 are primary and secondary intake valves, respectively. A spark plug 138 is arranged centrally between the four valves.

20        The first camshaft 110 is directly driven by the crankshaft through a toothed belt 140 passing over a toothed wheel 142. The first camshaft has cams 150 and 152 which act on the exhaust valves 114, 116 through cam  
25        follower buckets 156. The second camshaft 112 is driven by the toothed belt 142 through a phase change mechanism 144 which may comprise any suitable linkage to permit the second camshaft 112 to rotate relative to the first camshaft 110. The second camshaft 112 has a cam 158 which  
30        acts on the follower 162 of the secondary intake valve 120.

The primary intake valve is driven by a third cam 164 on the first camshaft 110 through a rocker 166 which is  
35        pivoted either on a shaft 168 ( as shown) or on a post. In this way, the relative phasing of the primary inlet valve 118 is fixed but the phasing of the secondary intake valve can be varied by the phase change mechanism 144.

Figure 4 shows schematically one cylinder of a multi-cylinder engine having twin overhead camshafts 10 and 12 and three valves per cylinder. The camshaft 10 passes over the valves of the exhaust ports 14 and the primary intake ports 16. The camshaft 12 on the other hand passes over the second intake ports 18 and over the spark plug holes 20. In this case, all the valves are operated directly by cams mounted on the respective camshafts 10 and 12, the primary intake valves and the exhaust valves being operated by cams on the camshaft 10 and the secondary intake valves being operated by the cams on the camshaft 12.

It is usual to have in an engine an exhaust manifold on one side and an intake manifold on the other. It is therefore preferred that both intake ports should enter the cylinder head from the same side of the engine. In the case of the embodiment of Figure 4, the intake ports branch off from the same intake duct 22. In the embodiment of Figure 5, on the other hand, two separate intake ducts 24 and 26 lead to the respective intake ports 16, 18 from the same side of the engine. It will also be noted that in Figure 5 the two intake ports are of unequal size.

In the case of the embodiment of Figure 6, as with the embodiment of Figures 1 to 3, each of the cylinders has two exhaust valves 30, 32 and two intake valves 34, 36. The spark plug 38 is arranged centrally between all four ports. The exhaust ports of each cylinder lie on opposite sides of the engine centre line as do the intake ports. One of the camshafts in this embodiment must control both exhaust ports and the primary intake ports while the other camshaft controls only the secondary intake ports. Because the exhaust valves are arranged on opposite sides of the engine centre line, one of the exhaust valves must be operated indirectly, such as by means of a rocker as earlier described.

In the three valve embodiments of Figures 4 and 5, the valves have been acted upon directly by the cams and the port arrangement has been modified in order to permit one intake valve and one exhaust valve to be operated by cams  
5 on the same camshaft. This however is not essential and it is alternatively possible to resort to a conventional port arrangement with one or two exhaust valves on one side of the engine centre line and two intake valves on the other and to operate one set of intake valves  
10 indirectly through the action of rockers following intake cams on the exhaust camshaft. Such an arrangement is not the most preferred from the point of view of ease of manufacture.

15 In all the described embodiments, if it is desired to use late inlet valve closing in order to reduce the engine volumetric efficiency, then it is only necessary to introduce a phase shift between the two camshafts. The camshafts can be solid and there is no necessity to resort  
20 to hollow camshafts.

It is possible either to alter the phase of both camshafts relative to the engine crankshaft or only the phase of the second camshaft 12. In the latter case the exhaust  
25 timing remains constant and the effect of the relative phase shift is only to alter the duration of the intake valve opening in each cycle.



## CLAIMS

1. A twin cam engine having a primary and a secondary inlet valve (118, 120) for each engine cylinder  
5 and means (144) for varying the opening phase of the secondary inlet valves (120) relative the primary inlet valves (118), wherein the first of the overhead camshafts (110) is provided with cams (150, 152, 164) for all the exhaust valves (114, 116) and the primary inlet valves  
10 (118) and the second camshaft (112) is formed with cams (158) for only the secondary inlet valves (120), whereby phase shifting of the second camshaft (112) relative to the first camshaft (110) causes a phase shift between the secondary inlet valves and the primary inlet valves  
15 without affecting the exhaust event.

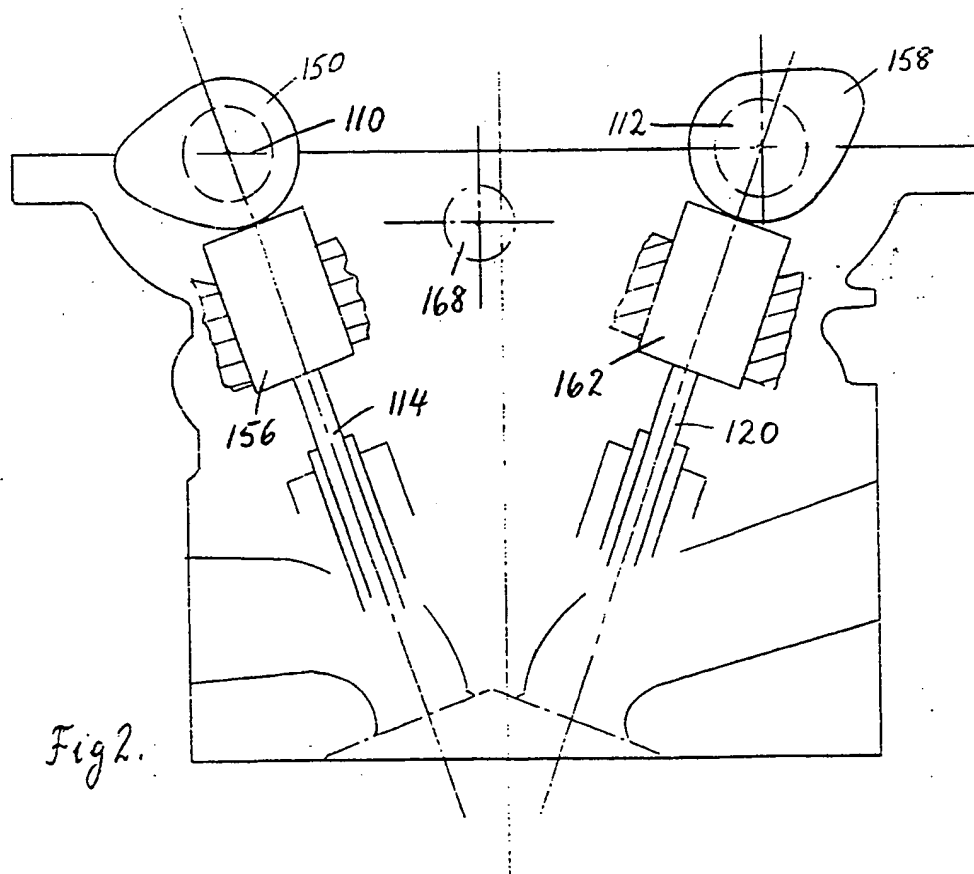
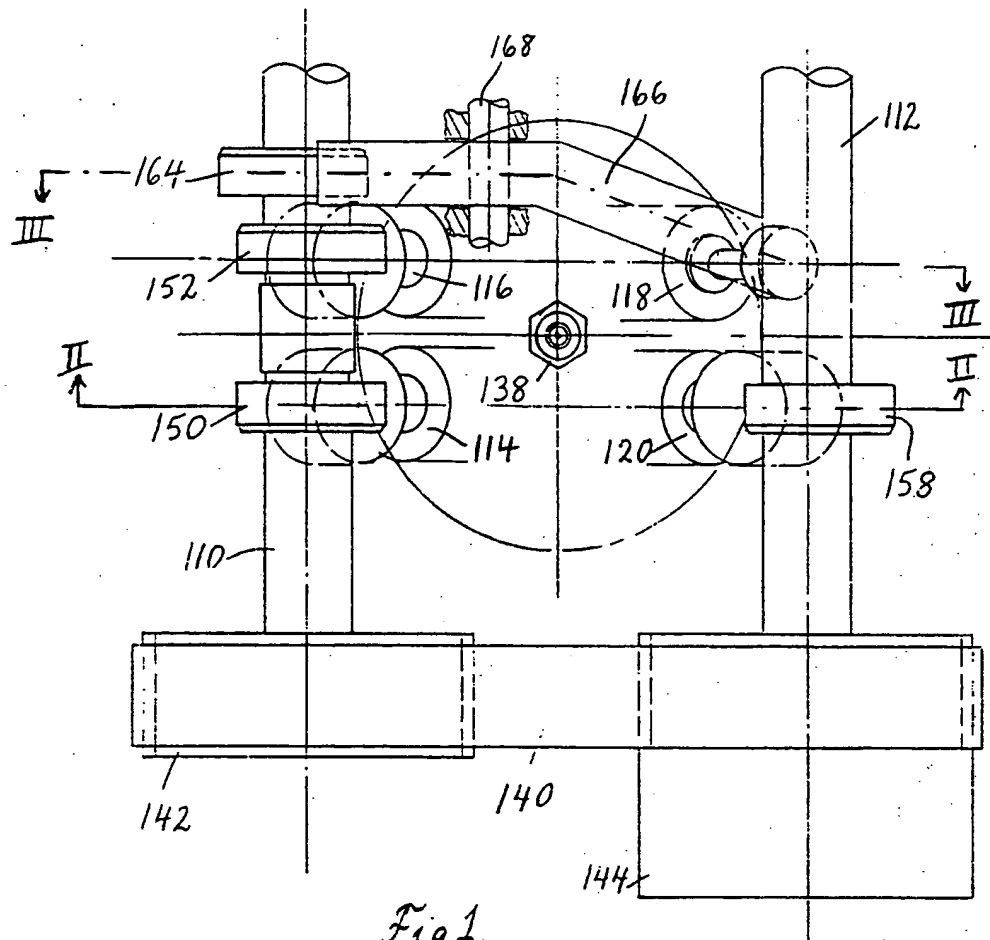
2. An engine as claimed in claim 1, wherein the ports are arranged with all the inlet valves lying on one side of the engine centre line and the exhaust valves on the  
20 other and wherein cams (164) on the first camshaft (110) act on the primary inlet valves (118) by way of rockers (166).

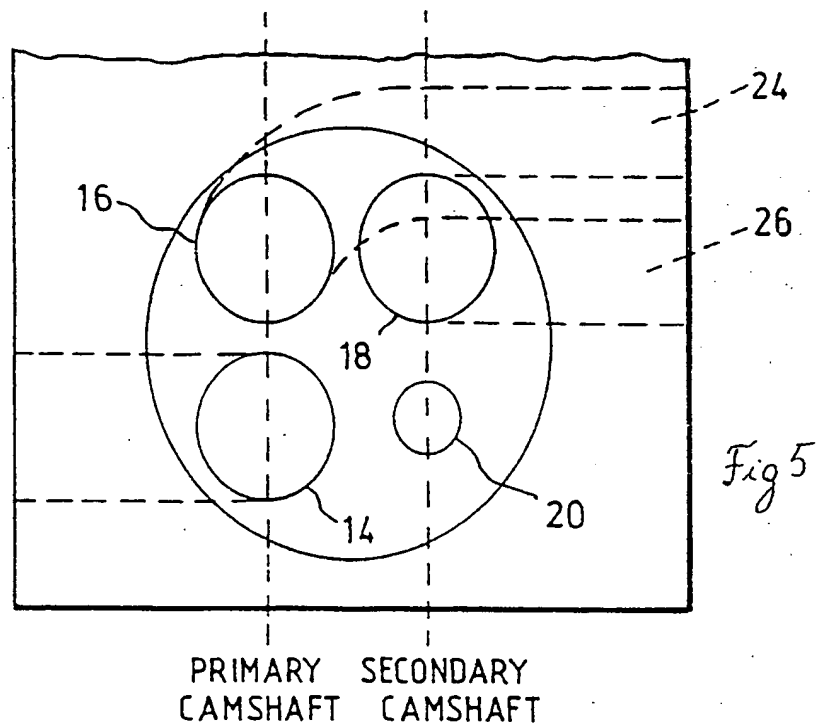
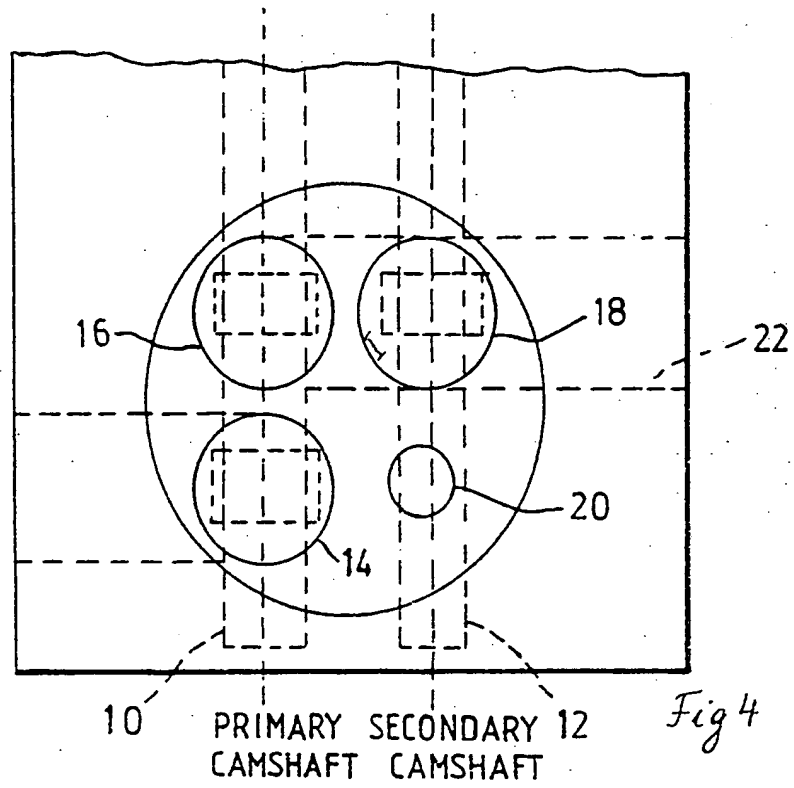
3. An engine as claimed in claim 1, wherein the  
25 primary intake valves are arranged on same side of the engine centre line as the, or one set of, exhaust valves and are directly operated by cams mounted on the first camshaft which includes cams for the exhaust valves.

30 4. An engine as claimed in claim 3, wherein the intake ducts for the primary valves cross the engine engine centre line to the same side as the intake ducts for the secondary inlet valves.

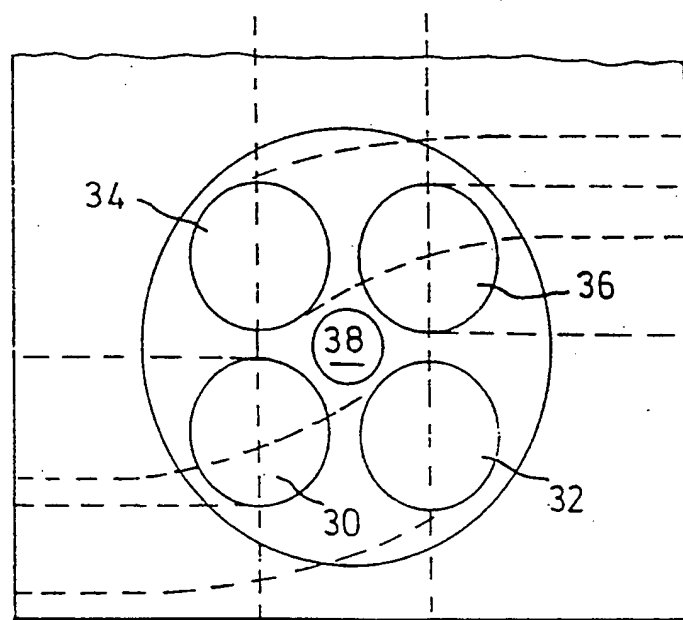
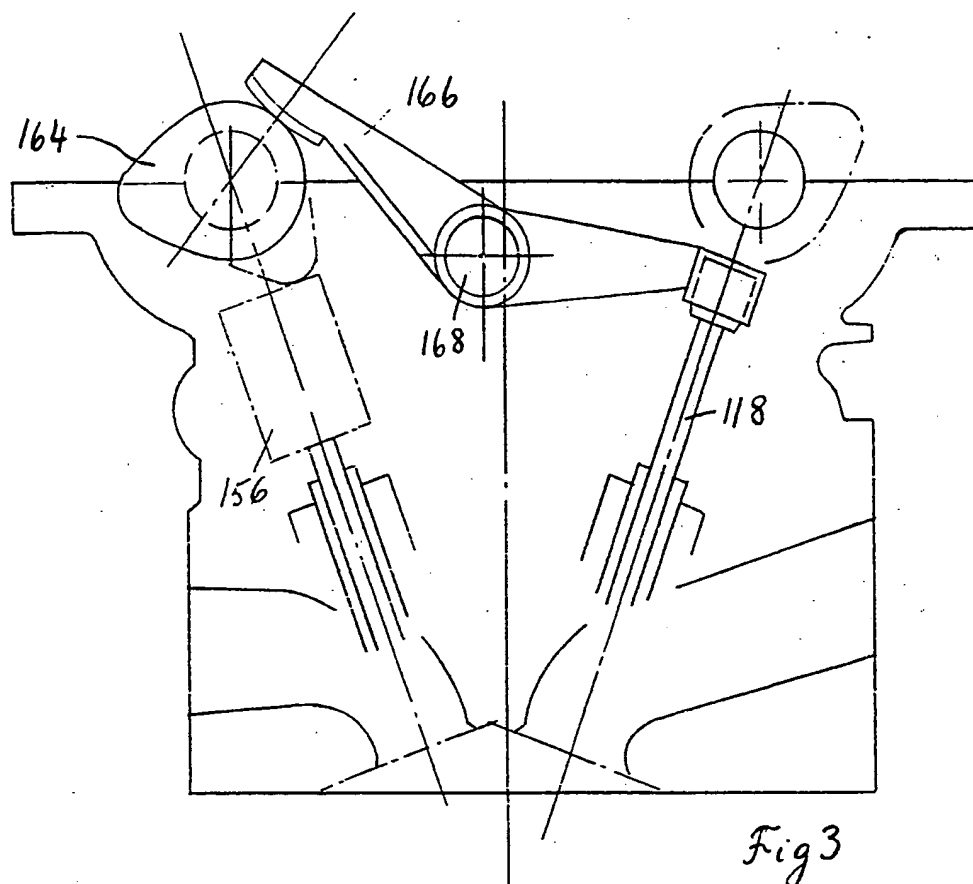
35 5. An engine as claimed in claim 4, wherein the primary and secondary intake ports have separate intake ducts opening onto the same side of the cylinder head.

1/3





3/3



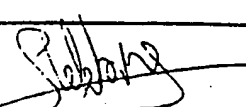
PRIMARY CAMSHAFT      SECONDARY CAMSHAFT

Fig. 6

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 90/00269

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) <sup>a</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC Int.Cl. 5 F01L1/26 ; F01L1/34		
II. FIELDS SEARCHED		
Minimum Documentation Searched		
Classification System	Classification Symbols	
Int.Cl. 5	F01L	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched <sup>a</sup>		
III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>a</sup>		
Category <sup>1</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	PATENT ABSTRACTS OF JAPAN vol. 10, no. 115 (M-474)(2172) 30 April 1986, & JP-A-60 247008 (MAZDA) 06 December 1985, see the whole document.	1, 2
A	EP,A,209426 (PEUGEOT) see page 3, line 10 - page 4, line 3; figures 1-3	3-5
A	DE,A,1751401 (KLAUE) see page 2, lines 13 - 34; figures 1-3	1
<p><sup>a</sup> Special categories of cited documents: <sup>10</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"I" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
28 MAY 1990	21. 06. 90	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	LEFEBVRE L.J.F. 	

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO. GB 9000269**

SA 35347

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.  
The members are as contained in the European Patent Office EDP file on

The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 28/05/90

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-209426	21-01-87	FR-A, B 2584455 DE-A- 3661092	09-01-87 08-12-88
DE-A-1751401	18-02-71	None	